Economics 2 | Professor Christina Romer
Spring 2020 | Professor David Romer

LECTURE 17

March 31, 2020

CAPITAL AND INTEREST

I. OVERVIEW

A. Our aggregate production function framework

B. The role of capital in growth

C. Terminology: capital versus investment

D. Where we are headed

II. RENTAL MARKET FOR CAPITAL

A. Profit maximization and the demand for rental capital

B. Supply and equilibrium

C. Complications when we think about a firm buying rather than renting capital

III. PRESENT VALUE

A. Time preference and definition of present value

B. Present value of a single payment to be received in the future

C. Present value of a stream of payments to be received in the future

IV. PURCHASING CAPITAL AND THE INVESTMENT DEMAND CURVE

A. Profit maximization and a firm's decision about how many machines to buy

B. The investment demand curve

C. The real interest rate and the investment demand curve

1. The distinction between the nominal and real interest rate

2. Why investment demand depends on the real interest rate

D. Shifts in the investment demand curve

Economics 2
Spring 2020

Christina Romer
David Romer

LECTURE 18
Capital and Interest

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Announcements

- You should have handed in Problem Set 4, Part 2.
    - If you were not able to complete it on time, please contact your GSI.
- We sent you a long email over the weekend about Midterm 2 and grading.
    - Please read it!

Announcements

- Grading:
  - The default grading option for all courses this semester is P/NP.
  - You are welcome to switch your grading option to a letter grade.
  - The Economics Department has adjusted its criteria for admission to the major so that there is neither any potential benefit nor any potential cost to taking prerequisites this semester for a letter grade rather than P/NP.
  - ***Regardless of your grading option, continue to work hard and to learn as much as you can.***

Announcements

- Midterm 2:
  - Tuesday, April 7, 2:00–3:30 p.m. (PDT).
  - If you would prefer to take it 10:00 – 11:30 p.m. (PDT), email Todd Messer (messertodd@berkeley.edu) ***by 5 p.m (PDT) this Friday (April 3)***.
  - The exam will be distributed and submitted through Gradescope.
  - DSP students: If you do not receive an email from Todd Messer by April 3, please contact him.

Announcements

- Midterm 2:
  - We will do a trial run this weekend: We will distribute a short assignment through Gradescope. You need to do the assignment and upload it to Gradescope by 5 p.m. (PDT) Monday (April 6).
  - It is important that you do the trial run!

Announcements

- Midterm 2 Ground Rules:
    - Open book and open note: You may use official class resources (book, slides, problem set answer sheets, and your notes).
    - Not open internet: You may not use anything else—you may not confer with other students in any way, or use any non-class-provided resources.

Announcements

- Midterm 2 Format: Similar to Midterm 1.
- Midterm 2 Coverage:
    - Everything up to and including lecture on Thursday, April 2 (Saving and Investment in the Long Run).
    - There will be no questions ***solely*** about material from before Midterm 1.

Announcements (continued)

- Hints for Studying:
  - ***Study and prepare just as you would for a traditional, closed-note exam.***
  - Start now!
  - Review lecture notes and slides; study problem set suggested answers.
  - Study (remotely) with other students.
  - Pose yourself problems; pose one another problems.
  - Do the sample midterm by yourself.

Announcements (continued)

- Places to Get Help:
  - Sample midterm.
  - Professor and GSI office hours.
  - In place of a review session:
    - ***Sketches*** of answers to the sample midterm will be posted this evening.
    - Each GSI will have an extra hour of office hours.

I. Overview

Aggregate Production Function

(1) $$\frac{Y^*}{POP} = \frac{Y^*}{N^*} \cdot \frac{N^*}{POP}$$

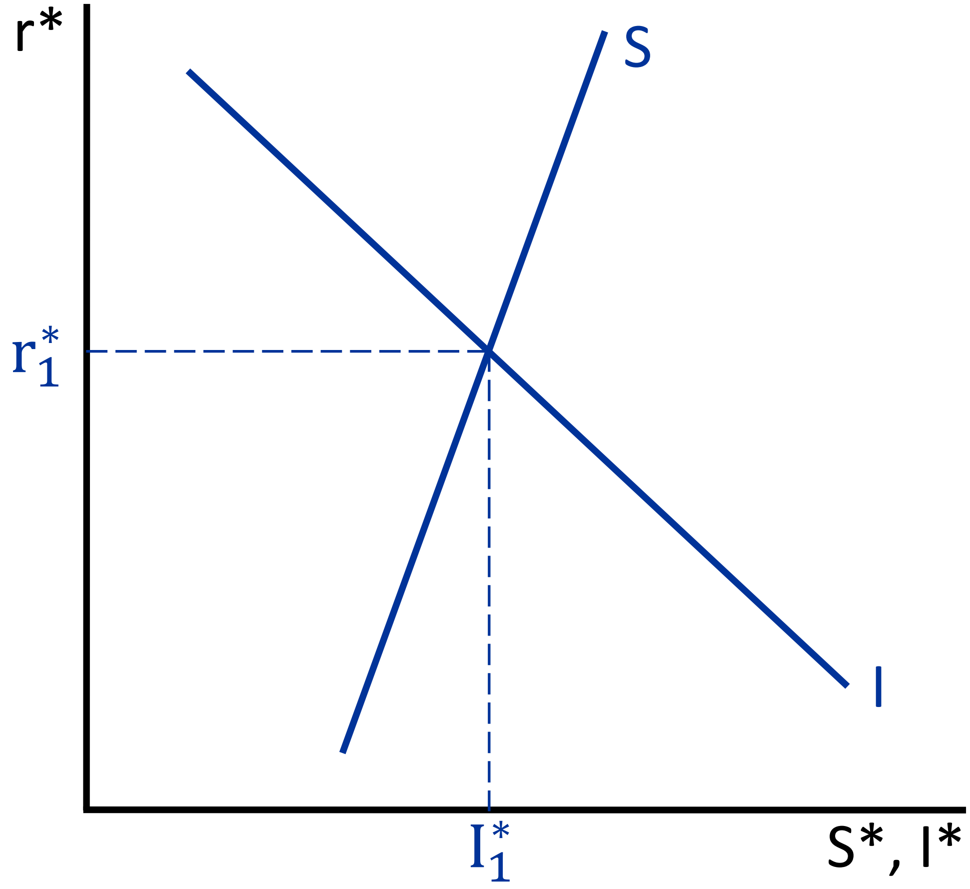
(2) $$\frac{Y^*}{N^*} = f\left(\frac{K^*}{N^*}, T\right)$$

(3) $$\boxed{\frac{Y^*}{POP} = f\left(\frac{K^*}{N^*}, T\right) \cdot \frac{N^*}{POP}}$$

Capital and Investment

- Capital: The accumulated ***stock*** of aids to the production process that were created in the past.
- Investment:
  - ***Changes*** in the capital stock.
  - That is, the construction or purchases of ***new*** machines and structures.

Where We're Headed: The Long-Run Saving and Investment Diagram



Here S is saving, I is investment, and r is the real interest rate (and * denotes a long-run value).

Other Reasons for Being Interested in These Issues

- Helps us understand the determination of the long-run or normal real interest rate.
- Helps us understand the determination of capital income.
- The investment demand function is important to understanding short-run macroeconomic fluctuations.

II. The Rental Market for Capital

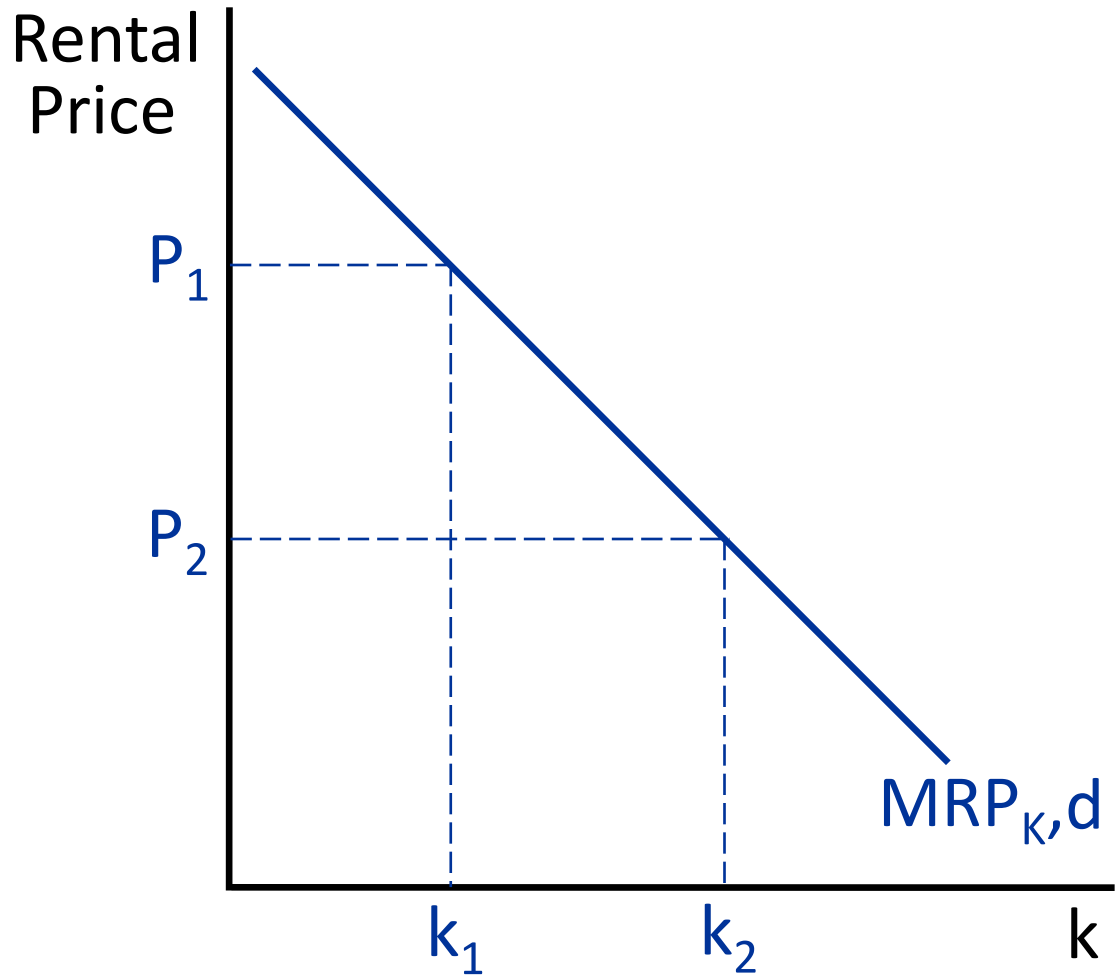
How much capital does a firm want to rent?

- Its decision is based on profit maximization.
- The firm looks at the MRP of another machine:

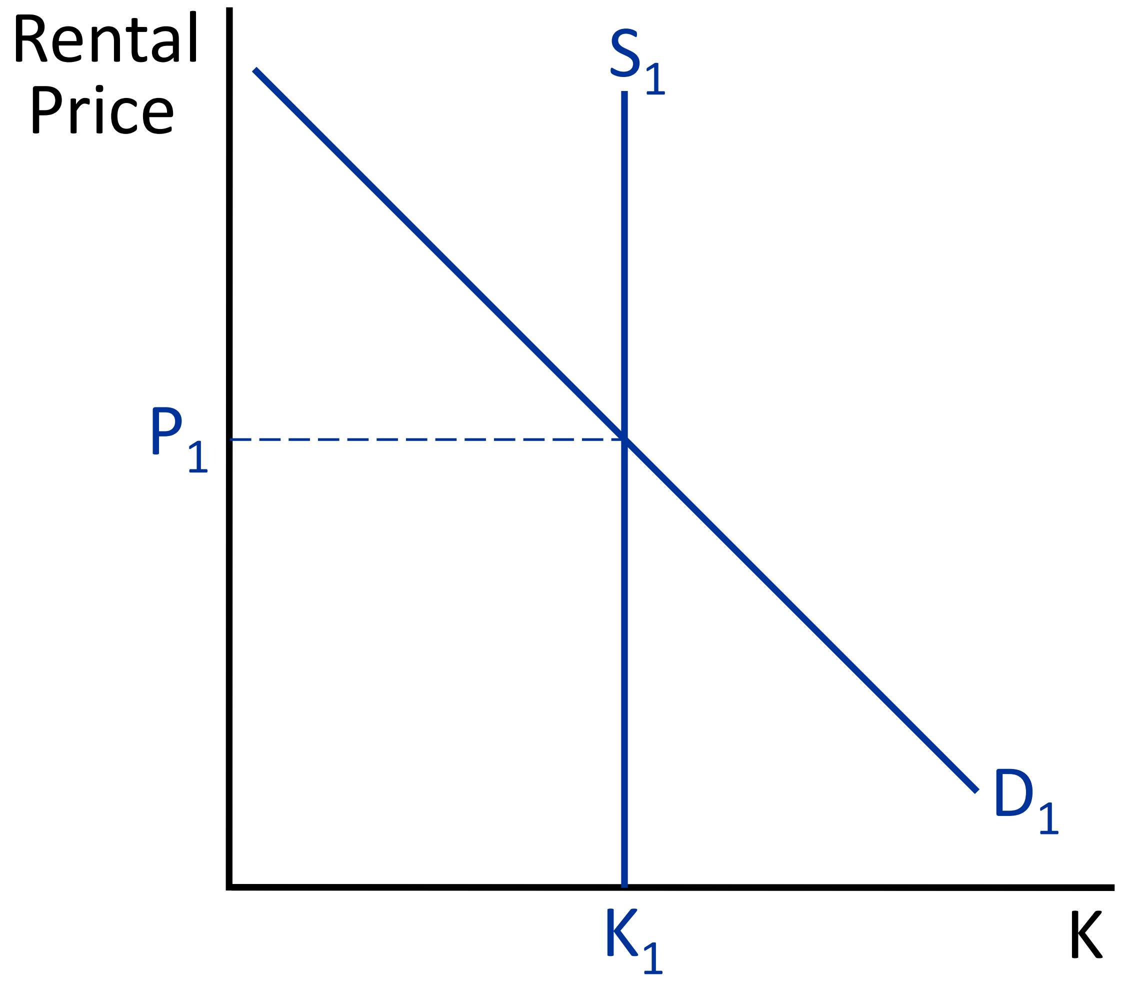
$$MRP_K = MP_K \bullet MR$$

- MRP_K declines as more machines are rented.
- The firm wants to rent machines up to the point where MRP_K = Rental Price.

A Firm's Demand Curve for Rental Capital



Rental Market for Capital



Two Limitations of This Analysis

- It doesn't help us understand how many new machines are purchased—that is, investment.
- It ignores the fact that firms typically buy machines rather than rent them.

III. Present Value

Present Value

- What something to be received in the future is worth today.

- Note: ***To start with, let's assume that there is no inflation or deflation***, so that the amount of goods and services that can be purchased with a dollar is the same in the future as it is today.

What We Mean by an “Interest Rate”

- For a saver: The percentage increase in your balance if you didn’t make any deposits or withdrawals.

- Similarly, for a borrower: The percentage increase in your balance if you didn’t make any payments or do any additional borrowing.

Present Value of a Single Payment to Be Received at Some Future Date

- In general: The present value is how much you would need to put in the bank to get the amount of that payment in the future.
- Think of the present value as an answer to a question: “How much money would I have to put in the bank today to have the amount of the payment at that future date?”

Example: \$1000 to be received a year from now, assuming the interest rate is 3% per year

- The present value, x, is the solution to:

$$x \bullet (1 + .03) \quad = \quad \$1000$$

$$x \quad = \quad \frac{\$1000}{(1 + .03)}$$

$$x \quad = \quad \$971$$

Example: Present value of $1000 one year from now, assuming the interest rate is 8% per year

$$x \bullet (1 + .08) = \$1000$$

$$x = \frac{\$1000}{(1 + .08)}$$

$$x = \$926$$

Example: Present value of \$1000 two years from now, assuming the interest rate is 3% per year

$$x \bullet (1 + .03) \bullet (1 + .03) = \$1000$$

$$x = \frac{\$1000}{(1 + .03)^2}$$

$$x = \$943$$

Present value of a single payment in the future

$$PV(F) = \frac{F}{(1 + r)^t}$$

- F = future payment
- r = annual interest rate (expressed as a decimal)
- t = number of years in the future the payment is to be received

Example: Present value of \$1000 each of the next three years, assuming the interest rate is 3% per year

$$\frac{\$1000}{(1+.03)^1} + \frac{\$1000}{(1+.03)^2} + \frac{\$1000}{(1+.03)^3}$$

$$= \quad \$970 \quad + \quad \$943 \quad + \quad \$915$$

$$= \$2828$$

Present Value of a Constant Stream of Payments

PV(Stream of F's) =

$$\frac{F}{(1+r)^1} + \frac{F}{(1+r)^2} + \frac{F}{(1+r)^3} + \ldots + \frac{F}{(1+r)^t}$$

- F = future payment in each year
- r = annual interest rate (expressed as a decimal)
- t = number of years in the future the last payment is made

Present Value of a Stream of Payments That's Different in Different Years

$$PV(\text{Stream of } F_n\text{'s}) =$$

$$\frac{F_1}{(1+r)^1} + \frac{F_2}{(1+r)^2} + \frac{F_3}{(1+r)^3} + \dots + \frac{F_t}{(1+r)^t}$$

- F_n = future payment in year n
- r = annual interest rate (expressed as a decimal)
- t = number of years in the future the last payment is made

IV. Purchasing Capital and the Investment Demand Curve

The Costs and Benefits of Buying a Piece of Capital

- The cost of a new machine (or some other piece of capital): The purchase price (paid immediately).
- The benefit of a new machine: Its marginal revenue product in each year of its life (received in the future).

What a machine is worth to a firm:

$$PV(\text{Stream of } MRP_K\text{'s}) =$$

$$\frac{MRP_K}{(1+r)^1} + \frac{MRP_K}{(1+r)^2} + \frac{MRP_K}{(1+r)^3} + \dots + \frac{MRP_K}{(1+r)^t}$$

- MRP_K = marginal revenue product of capital in each year
- r = annual interest rate (expressed as a decimal)
- t = lifespan of the machine

Profit Maximization Implies:

- Firms want to purchase capital up to the point where:

$$PV(\text{Stream of } MRP_K\text{'s}) = \text{Purchase Price}$$

- Note: If we want to be precise, since firms don't know exactly what the MRP_K's will be, it's really what they expect the MRP_K's to be that enters the condition for profit maximization.

Important Relationship

- We focus on the relationship between purchases of new capital and the interest rate.
- Why?
- We refer to purchases of new capital (additions to the capital stock) as investment.

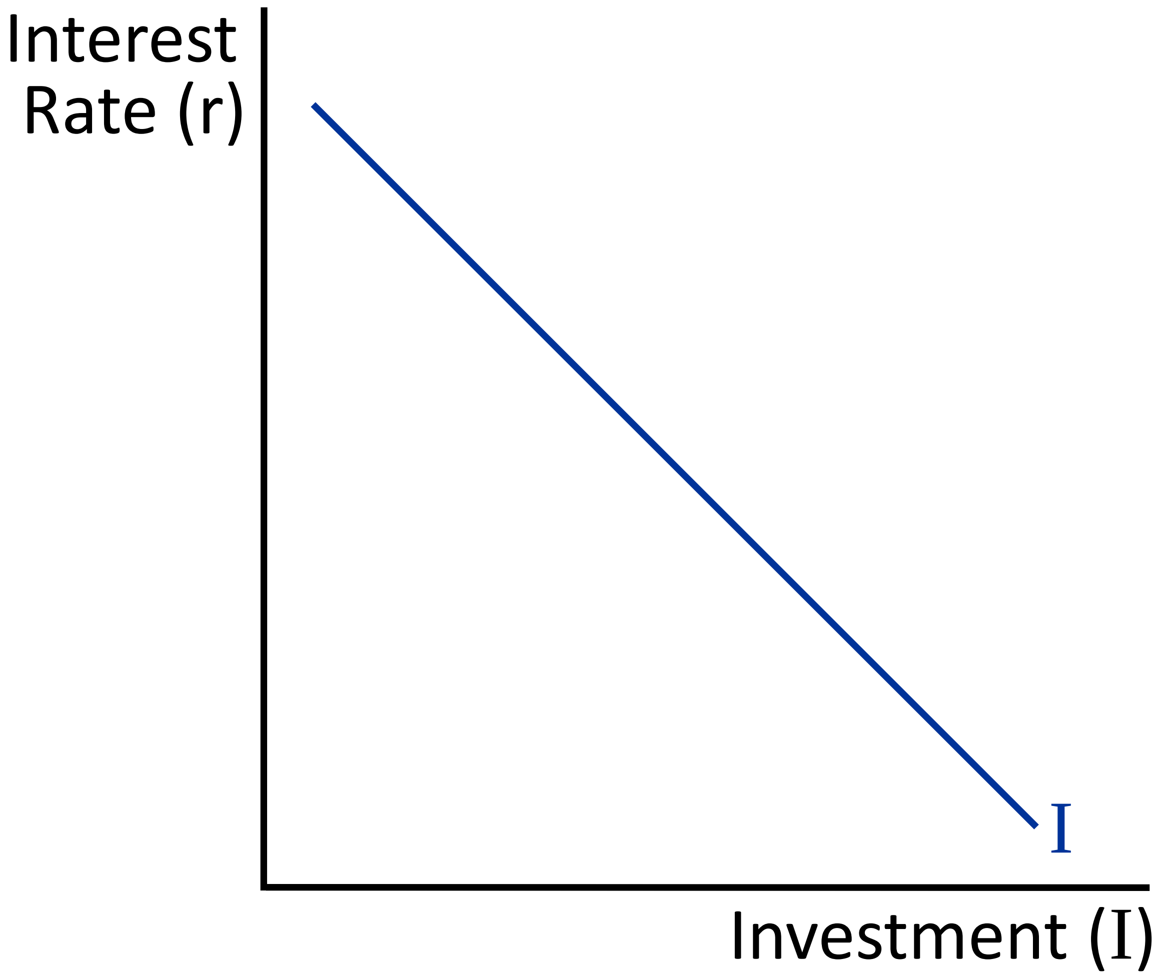
Why is there a negative relationship between purchase of new capital and the interest rate?

- Recall the condition for how much capital a firm wants to buy:

$$PV(\text{Stream of } MRP_K\text{'s}) = \text{Purchase Price}$$

- A term involving r appears in the denominator of expressions for present value: an amount to be received in the future is less valuable when the interest rate is higher.
- An increase in r therefore causes PV(Stream of MRP_K's) to fall.
- This makes firms want to buy less capital.

Investment Demand Curve



The Real Interest Rate and the Nominal Interest Rate

- ***Now, let's allow for the possibility of inflation.***
- Recall:
  - "Nominal" means measured in terms of dollars.
  - "Real" means measured in terms of goods and services. (Equivalently, adjusted for changes in prices.)

The Nominal vs. the Real Interest Rate

- Recall: The interest rate is the percentage increase in your balance if you didn’t make any deposits or withdrawals.

- The ***nominal*** interest rate therefore means the percentage increase in your balance ***measured in dollars*** if you didn’t make any deposits or withdrawals.

- The ***real*** interest rate means the percentage increase in your balance ***measured in terms of purchasing power (that is, adjusted for changes in prices)*** if you didn’t make any deposits or withdrawals.

The Relation between the Real Interest Rate (r) and the Nominal Interest Rate (i)

- The nominal interest rate has two components, compensation for inflation and the real interest rate:

$$i = r + \pi,$$

where π is the inflation rate.

- We can rearrange this as:

$$r = i - \pi.$$

- Aside: If we want to be precise, the relevant inflation variable is in fact the expected rate of inflation, not the actual rate of inflation.

The Relation between the Real Interest Rate (r) and the Nominal Interest Rate (i)—Example

- Suppose i = 10% and π = 10%.
- Then the nominal interest rate (the percent return you get in dollars) is 10%.
- But the real interest rate (the percent return you get in terms of the purchasing power of what you saved) is 0.

The Real Interest Rate and the Nominal Interest Rate—Computing Present Values of ***Nominal Amounts*** to Be Received in the Future

- To compute the present value of a ***nominal*** amount to be received in the future, you need to use the ***nominal*** interest rate.
- Example: What is the present value of $10,000 lottery winnings that will be paid a year from now?

$$x \bullet (1 + i) = \$10{,}000$$

$$x = \frac{\$10{,}000}{(1 + i)}$$

The Real Interest Rate and the Nominal Interest Rate—Computing Present Values of ***Real Amounts*** to Be Received in the Future

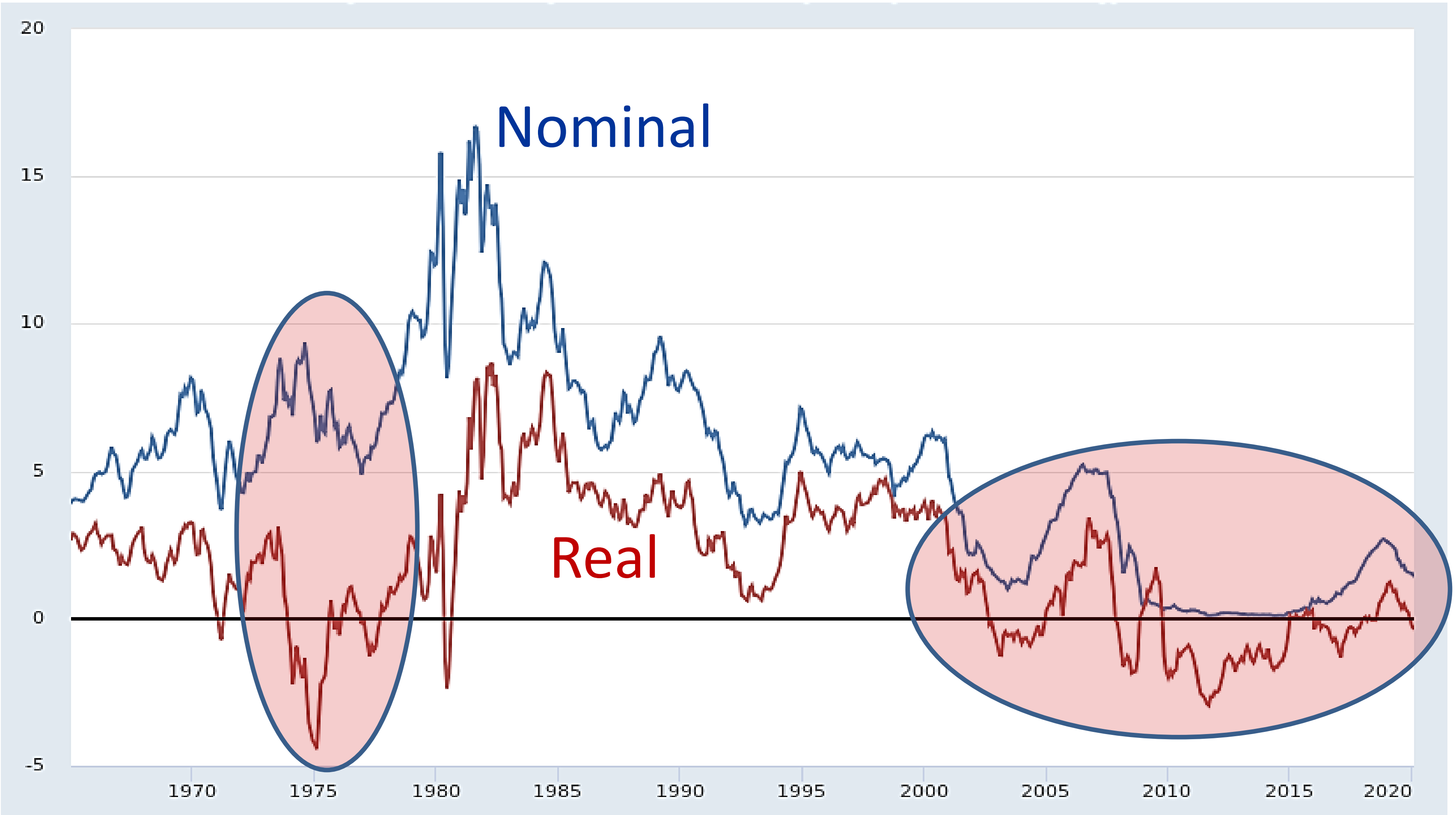
- To compute the present value of a ***real*** amount to be received in the future, you need to use the ***real*** interest rate.

- Example: What is the present value of a promise to pay you a year from now enough to buy a basket of goods that costs \$10,000 today?

$$x \bullet (1 + r) = \$10{,}000$$

$$x = \frac{\$10{,}000}{(1 + r)}$$

Nominal and Real Interest Rates (1-year nominal interest rate, and 1-year nominal rate minus 1-year inflation rate)



Source: FRED.

Why Investment Demand Depends on the ***Real*** Interest Rate—Version 1

- Recall: The firm buys new capital until:

  $$PV(\text{Stream of } MRP_K\text{'s}) = \text{Purchase Price}$$

- Think of measuring everything in this expression in real (that is, inflation adjusted) terms.
- Then, since we are computing prevent values of real amounts, the right interest rate to use in computing present values is the real interest rate.
- Thus, if i rises only because π rises, nothing in this expression changes, and so investment demand does not change. So, investment demand depends on the ***real*** interest rate.

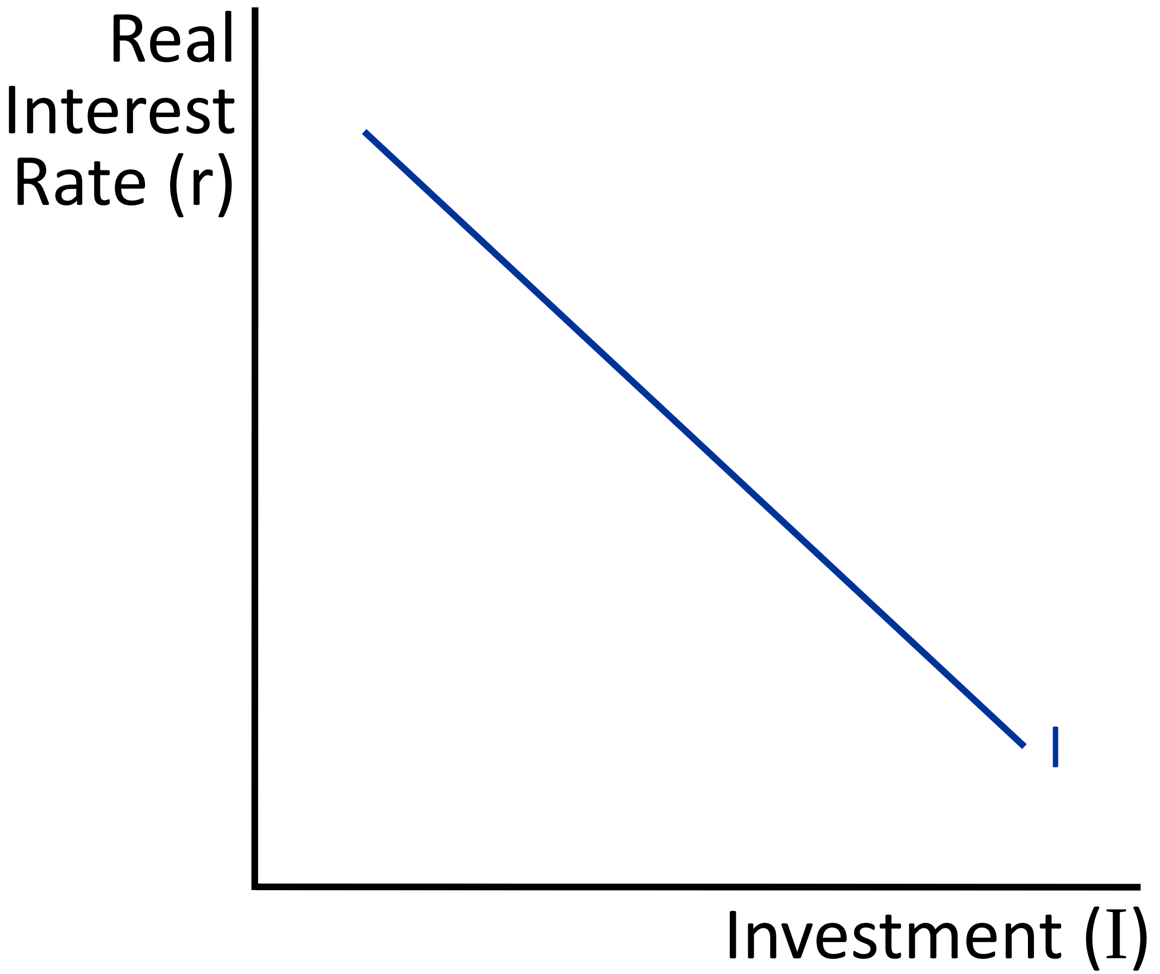
Why Investment Demand Depends on the ***Real*** Interest Rate—Version 2

- For a competitive firm, PV(Stream of Future MRP_K's)

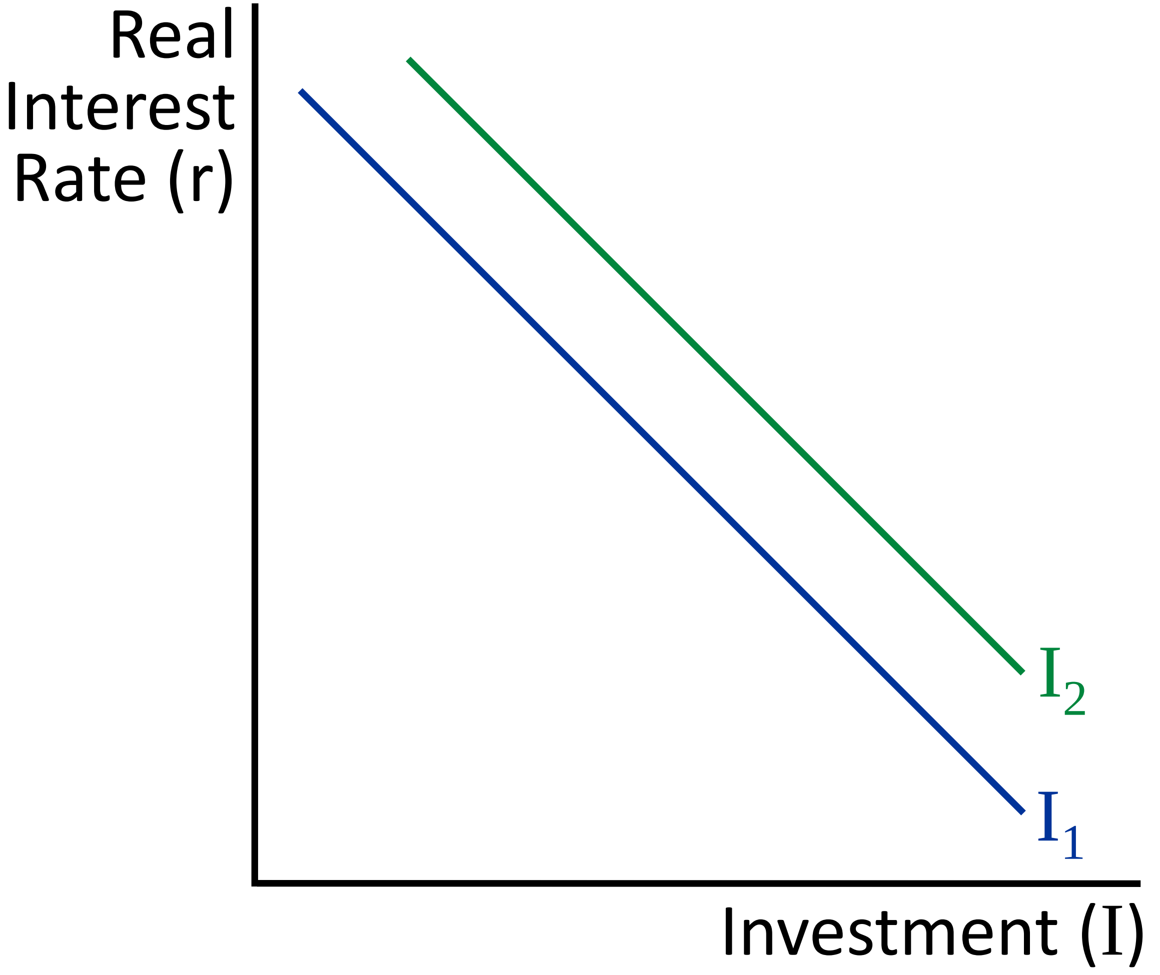
$$= \frac{MP_K \bullet P_1}{(1+i)^1} + \frac{MP_K \bullet P_2}{(1+i)^2} + \frac{MP_K \bullet P_3}{(1+i)^3} + \ \dots \ + \frac{MP_K \bullet P_t}{(1+i)^t}$$

- Recall that $i = r + \pi$.
- If i rises only because π rises, PV won't change because the P's will also rise.
- Only if i changes because r changes will PV change.
- Thus: Investment demand depends on the ***real*** interest rate.

Investment Demand Curve



Shifts in the Investment Demand Curve (Fall in the Purchase Price of Capital)



Shifts in the Investment Demand Curve (Pessimism about Future MRP_K's)